4104013001-00019-00

Chain-A Software Design Specification

for the

Generation-3
Personnel Safety System
(PSS)

of the

Advanced Photon Source

at

Argonne National Laboratory
9700 Cass Avenue
Argonne, Illinois 60439

WBS x.1.4.1.4.30.1

APPROVED BY

John Carwardine, Associate Division Director, Electrical System, ASD	**Date**
Greg Markovich, Group Leader, SI, ASD	**Date**
Monhan Ramanathan, Chairman, Adhoc Generation 3 committee	**Date**
Jim Lang, Radiation Safety,	**Date**

PREPARED BY

Anne Boron
SI, ASD

Date

REVIEWED BY

Roy Emerson,
SI, ASD

Date

Nick Friedman,
SI, ASD

Date

Jon Hawkins,
SI, ASD

Date

Marty Knott,
ESS, ASD

Date

NOTIFICATION OF SPECIFICATION REVISIONS

(INDEX) **INDEX OF PAGE REVISIONS**

PAGE NO.	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
REV. NO.	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00

PAGE NO.	16	17	18	19	20	21	22								
REV. NO.	00	00	00	00	00	00	00								

PAGE NO.															
REV. NO.															

PAGE NO.															
REV. NO.															

PAGE NO.															
REV. NO.															

PAGE NO.															
REV. NO.															

REVISION AUTHORIZATION

REVISION NUMBER	00	01	02	03	04	05	06	07	08
DCN NUMBER									
DATE									
APPROVED BY									

Table of Contents

1 Introduction

1.1 Purpose

This Software Design Specification contains the requirements used to develop the software for the Personnel Safety System (PSS) at the Advanced Photon Source at Argonne National Laboratory. This document will be used by the programmers to develop PSS code for the Chain-A PLC which performs one half of the redundant Emergency Shut Down (ESD) portion of the PSS systems.

2 Applicable Documents

The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein, and the contents of this specification, the contents of this specification shall supersede any other requirements.

2.1 Government Documents

- DOE ORDER 420.2, November 05,1998
- Accelerator Safety Implementation Guide for DOE O 420.2, Draft, May 1, 1999
- DOE ORDER 5480.25, November 03, 1992
- DOE GUIDANCE 5480.25, September 1, 1993

2.2 Non-Government Documents

- APS Safety Assessment Document(SAD), Rev 1, May 1998, Argonne National Laboratory, Argonne, IL
- Argonne National Laboratory Environment, Safety & Health Manual(ES&H), May 27, 1999
- SLAC Report 327, April 1988, Stanford Linear Accelerator Center, Menlo Park, CA
- NCRP Report No. 88, Issued 30 December 1986, National Council on Radiation Protection

2.3 APS Standard

- E000P-901100…Software Coding Standards for the Personnel Safety System of the Advanced Photon Source

2.4 APS Specifications

- 4104013001-00019-00…Software Coding Standards for the Personnel Safety System Chain "A"
- E000P-901100…Software Coding Standards for the Personnel Safety System of the Advanced Photon Source

2.5 PSS Specifications

- 4104013001-00014-00…Input/Output listings for the beamline Personnel Safety System Chain "A"
- 4104013001-00017-00…System Requirements Specification for the Beamline PSS
- 4104013001-00016-00…User Software Requirements Specification for the Beamline PSS
- 4104013001-00015-00…Software Requirements Specification (SRS) for the PSS

2.6 Other Publications

- Allen Bradley Control Logix Support Manual

2.7 Definitions, Acronyms and Abbreviations

The following are some of the frequently appearing or unique words or phrases used in this document. These definitions are provided as a quick reference for the reader's convenience.

Downstream: The direction defined by the path from the Storage Ring to the end of the last Station of a beam line. The beam flow is from the Storage Ring through the Front End Shutters into and through Station A and then to Station B and so on until the beam encounters either a closed Shutter or a beam stop at the end of the last Station.

Upstream: The direction defined by the path from the end of last Station of a beam line to the Storage Ring. The direction opposite the flow of the beam.

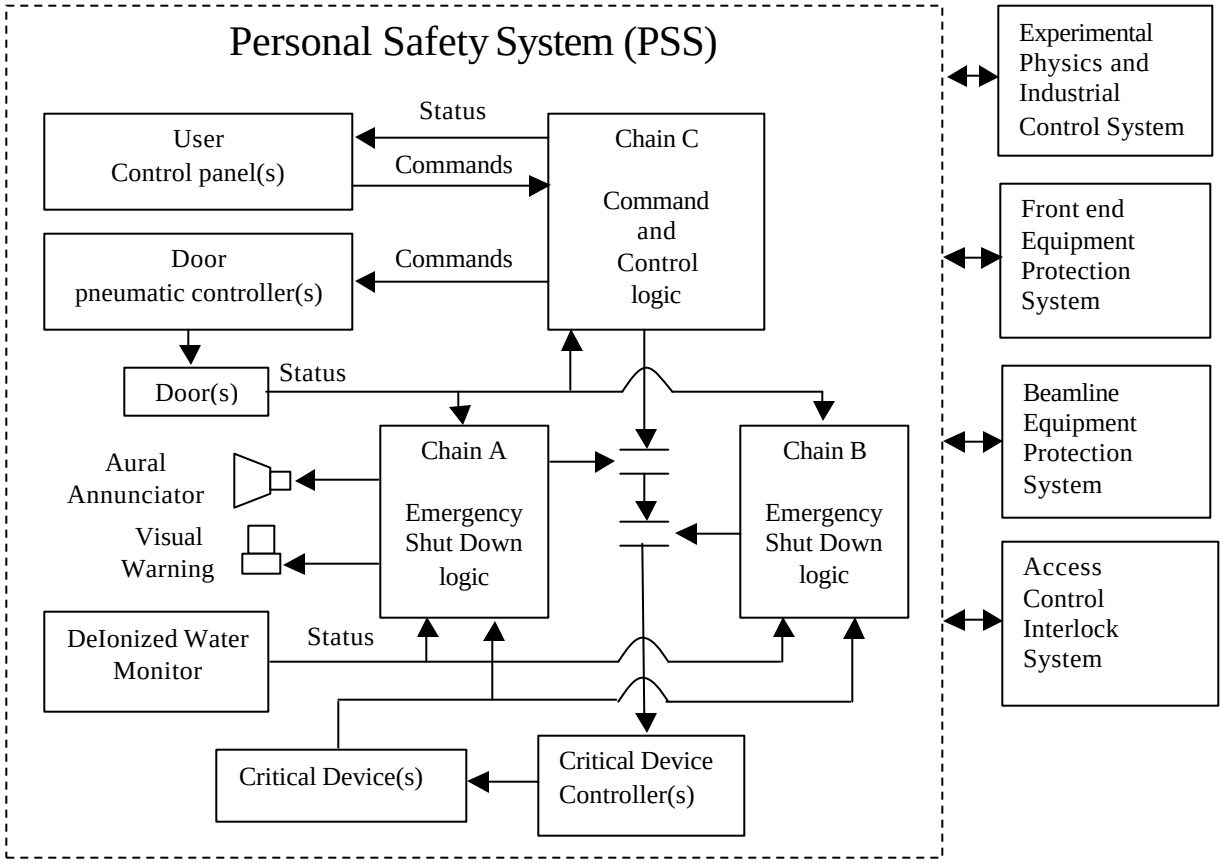
Synchrotron Radiation:

ACIS	Accelerator Control and Interlock System
APS	Advanced Photon Source
ASD	Accelerator Systems Division
BLEPS	Beamline Equipment Protection System
C&C	Command and Control system
CPU	Central Processing Unit
DOE	Department of Energy
ES&H	Environment, Safety & Health Manual
EPICS	Experimental Physics and Industrial Control System
EPS	Equipment Protection System
ESD	Emergency Shut Down system
FEEPS	Front End Equipment Protection System
FOE	First Optics Enclosure
I/O	Input Output
IOC	Input Output Controller
LAN	Local Area Network
NCRP	National Council on Radiation Protection
OI	Operator Interface
PSS	Personnel Safety System
PLC(s)	Programmable Logic Controller(s)
PMD	Programmable Message Display
SAD	Safety Assessment Document
SLAC	Stanford Linear Accelerator Center
SRS	Software Requirements Specification
TBD	To Be Defined/Decided
VME	Versa Module Eurocard
XFD	Experimental Facilities Division

3 Operational Concepts

3.1 Overview

The PSS shall consist of two redundant Emergency Shut Down (ESD) subsystems and a separate command and Control (C&C) subsystem (see system constrains 2.5.1.2 & 2.5.1.3), which in turn interface with systems that control other aspects of the facility. The following block diagram shows the relationships between the major subsystems within PSS and its relationship to the other systems.



Hardware Interface Diagram

3.1.1 Rationale

The PSS system is a system of permits or enables that allow the safe use of an experimental station. Three PLCs from different manufacturers are used to minimize the likelihood that a hardware defect or a programming software package defect would be common to all three and cause simultaneous unsafe operation. The input to the PLCs is through independent sensors and wiring to eliminate the possibility that a single sensor or wire failure will cause improper operation. The output of the PLCs are in series requiring all have to be in agreement for operation of critical devices. Additionally, three different programmers are used to implement the control code used in the Chain-A, Chain-B and Chain-C PLCs to minimize the chance of propagating a human error from one system to the others.

4 Program Design General

4.1 Overview

There are three independent control/monitoring systems for the beamline station PSS (Personnel Safety System). For each beamline these systems are named Chain-A, Chain-B and Chain-C.

The Chain-A system is the primary system providing both PSS monitoring and control. The Chain-B system provides redundant monitoring at all times, and shut down control in the event the Chain-A system should fail. Note that both systems must agree it is safe to allow beam into the Experimental station. Either system may withdraw its enable permits causing the FES (Front End Shutters) or associated critical device to close (or in the extreme case) dump the Storage Ring. Chain-C provides the operators interface.

4.2 Chain-A Programming Language

Chain A Programming is accomplished using ladder logic programs written in accordance to the guidelines set forth by Rockwell Automation for the Control Logix Platform.

4.3 Ladder Logic Control Overview

A Ladder Logic Control program consists of one or more tasks to be performed by the Logic Processor sequentially scanning a series of Boolean equations. A task describes a requirement the program must fulfill. This description is provided by defining the necessary equations needed to accomplish the task. A task can be in only one state at any instant in time. As the program moves from state to state, the functions defined in the states accomplish the task. The program scan proceeds sequentially from beginning to end. However, because there is no output to the real world until the end of this scanning process, the effect is as if all of the logic is solved in parallel. There are times when it is necessary to exploit the actual scanning process such as at power up of this program. However, most of the time it is more of an advantage to view the program as if all tasks are simultaneously occurring.

5 Program Design Narrative

This section of this document contains a narrative for each of the tasks in the Chain A control program. Together, these tasks comprise the complete program. Each task has a purpose and the method(s) required to accomplish the purpose defined for it.

5.1 Programming Language

The Chain A PLC will be programmed in ladder logic. Ladder logic is a programming language that uses the ladder relay diagram metaphor. It consists of 'rungs' of inputs connected to outputs. It does not contain any inherent looping constructs and function calls which are typical to many languages. In ladder logic, outputs not explicitly set on are set off. Outputs can only be set from one place in the code. This restriction causes some convolutions to the logic. Ladder logic is the manner in which PLCs are programmed.

5.2 Design Overview

The design should be thought of as consisting of two separate but related parts. The first part deals with the function of the beamline as a whole. The second part deals with the activities associated with the experimental stations. Both of these parts are implemented as state machines. Although the experimental station states can depend on beamline states, the design is simplified by keeping the two as separate as possible. Beamline and Experimental Station State Machine Description

The SRS requires that the beamline support a state machine consisting of 5 states or modes. A state machine consists of a description of the states and the conditions that cause a transition from one state to another. In each state the outputs are set to a pre-defined level. The SRS defined operational states or modes will translate into program states. Ladder logic is able to support simultaneous state machines within a single program. The bulk of the PSS ladder logic code can be described by a single state machine, other functions (i.e. Search subroutines) are not cleanly described by an inclusive state machine. Such functions are described separately. The various state machines are described in the following text. Functional Modes.

The functional modes or states that will be supported by the software contain the basic requirements of the PSS system for Chain A.

5.2.1 Open Access.

While in an open access mode the Chain A software will remove their shutter permits. It will not be possible to open any shutters for any stations.

5.2.2 Search and Secure.

The search and secure functions will be performed by Chain A and the search and secure status will be provided to Chain B and Chain C. The search and secure process is defined previously in this document. Chain A, Chain B, and Chain C therefore have information as to this status. Search and secure is a prerequisite to the Beam Ready mode.

5.2.3 Restricted Access.

After completing a successful search and secure procedure the station that was searched has a restricted access classification. While a station is in the restricted access mode, the station is ready to receive beam. The restricted access mode will be terminated if any station door is opened or any station emergency stop is pushed in.

5.2.4 Beam Ready.

Beam Ready is a significant mode of the PSS. The Beam Ready mode signals that all of the conditions required for a station to receive beam are currently met. The station will be identified as beam active as soon as the shutters are opened. For the PSS to be Beam Ready for a station the following conditions must be continuously met:

- The PSS must have the ACIS Global On-Line permit.
- The PSS must have the ACIS Storage Ring permit.
- The shutter manifold pressure must be > 60 P.S.I..
- The PSS must have the shutter permit for the shutter to be opened. The FE-EPS permit must be present for the Front End Shutters and the BL-EPS permit must be present for downstream shutters.
- There must not be a Minor fault.
- There must not be a Serious fault.
- There must not be a Major fault.
- The APS key must have been enabled by the floor coordinator.
- The station must be in a Restricted Access Mode.
- If the station is protected by a Mode shutter a valid Mode must be selected.

5.2.5 Beam Active.

A station will be identified as Beam Active when it was previously in the Beam Ready Mode and the user has caused the station's shutter (Critical Device) to open and there is beam available at the station's shutter. For example: Station B may be Beam Ready and its shutter may be open, but Station B is not Beam Active until the Front End Shutters are opened. This example requires a shutter for Station B between Station A and Station B.

5.3 Program Modules

The following program modules implement the Chain A states required by the PSS Beamline SRS.

5.3.1 Init

The Init module is run once upon power on of the processor. It is used to start the program from a known initial state. This is accomplished by clearing all data storage areas to zero and additionally setting all timer preset values to their desired value.

5.3.2 Beamline

The beamline module is the largest module of the program.

The following functions are implemented in this module:

- Watchdog timer generation and monitoring.
- Timer functions for blinking indicators at two different rates.
- Fault detection for non Station related faults.

5.3.3 EPICS Communications

EPICS communications is controlled totally within this subroutine. Once per second the status of the Chain A PLC is sent to the EPICS IOC through an Allen-Bradley Direct Communication Module (DCM). This status includes the complete input and output image tables of the processor. Additionally, the status of each shutter and any recorded fault conditions are also sent to EPICS.

5.3.4 Station Search

Interlock search devices will be provided and are used to conduct an orderly search of the experimental station(s) to insure that there is no one in the station before beam is allowed in the station.

The program will provide a sequenced search by blinking in order each search device in the order that the person performing the search must visit the devices. When the searcher has arrived at a search device, a button will have to be pushed to inform the PSS that the user has searched a particular area. When this button is pushed, the PSS will indicate to the user the receipt of the signal by stopping the blinking and displaying a continuously ON indicator. The PSS will then repeat this process until all search devices have been visited.

The search process is a time controlled sequence monitored by the PSS. The sequence normally concludes when the last or only door of an experimental station is closed. If the user fails to search the station in the correct order or in the allocated time the search process will be aborted by the PSS.

While conducting an Interlocked Search, the PSS will provide an audible announcement of the message “Searching station x” where x is the actual station identifier. Stations are identified as A, B, C etc.

There are two mandate conditions that must be achieved when searching an experimental station.

- The PSS must continue the search message for 20 seconds after the last door is closed.
- During this 20 second period after door closure, the PSS must not enable the station to receive beam.

Should the user fail to search the station in the correct sequence or in the allocated time, the PSS will abort the search process and notify the user with the audible message “Search aborted”.

There will be one or more visible indicators in each experimental station to indicate when a search and secure procedure is in progress. The PSS will enable these devices for the duration of the search procedure. An acceptable device is a strobe light.

6 Program Design Details

This section contains a narrative for each of the Chain-A control devices. These devices, when combined, comprise the complete function of Chain-A controls.

6.1 Mezzanine Master PLC

This section describes the mezzanine master PLC functions and interfaces.

6.1.1 Match Keying Number

The program and beamline keying number must exactly match. The program will not run and the PLC will enter alarm mode if the configured software and hardwire key do not exactly match.

6.1.2 Watch Dog From Chain-B

The program monitors the Chain-B 0.5 Hz pulse. The signal determines whether the Chain-B controller is functioning This monitored condition has various outcomes:

- When the beamline is Beam Active: When the pulse is not ON, the program will fault and remove a permit from the critical device.
- When the beamline is in any other condition: When the pulse is not ON, the program will enter an alarm state and will not issue a permit to the critical device.

6.1.3 Watch Dog To Chain-B

The program generates a 0.5 Hz pulse signal to the Chain-B controller.

6.1.4 CPU Key Switch

The key switch enables the controller to enter one of three operating modes:

- Remote: This key position allows remote control of the PLC CPU.
- Program: This key position disables all control outputs and allows the operator to download code to the CPU.
- Run: This key position enables the running of the downloaded program and all of the associated changes of state to the field devices wired to the PLC.

6.1.5 PLC Battery

The CPU's backup battery prevents the loss of PLC memory in the case of power failure.

When the battery is disconnected or its power is below operating range for more than ?? seconds, the program will generate a fault and withhold or remove the permit(s) to critical devices as detailed below:

- When the beamline is beam active: If the CPU battery falls below operating range, the program will fault and remove the permit(s) to critical devices.
- When the beamline is in any other condition: If the CPU battery falls below operating range, the program will alarm and will withhold permit(s) to critical devices.

6.1.6 Remote I/O Communication

The station remote I/O communications, via ControlNet.

- When the beamline is Beam Active: If the remote I/O communications link is lost, the program will fault and remove permit(s) to critical devices.
- When the beamline is in any other condition: If the remote I/O communications link is lost, the program will alarm and will withhold permit(s) to critical devices.

6.1.7 Test Interface Door

Interface door close switch test. This is the test cart interface portal for PSS program validation.

- When the beamline is Beam Active: If the interface door test switch input is OFF, the program will fault and remove permit(s) to critical devices.
- When the beamline is in any other condition: If the interface door test switch is OFF, the program will alarm and will withhold permit(s) to critical devices.

6.1.8 ACIS Global-Online

Permit to access stored beam.

- When the beamline is Beam Active: If the ACIS Global Online permit is OFF, the program will close the FES and remove permit(s) to critical devices.
- When the beamline is in any other condition: If the ACIS Global Online permit is OFF, the program will withhold permit(s) to critical devices.

6.1.9 ACIS Shutter Permit

Permit to the Front End Shutter.

- When the beamline is Beam Active: If the ACIS FE permit is OFF, the program will close the FES and remove permit(s) to critical devices.
- When the beamline is in any other condition: If the ACIS FE permit is OFF, the program will withhold permit(s) to critical devices.

6.1.10 FEEPS Shutter Permit

Permit to the Front End Shutter.

- When the beamline is Beam Active: If the FEEPS shutter permit is OFF, the program will close the FES and remove permit(s) to critical devices
- When the beamline is in any other condition: If the FEEPS shutter permit is OFF, the program will withhold permit(s) to critical devices.

6.1.11 FE Shutter Disable Confirm (<3PSI)

FES pressure feedback air valve. Indicator for the FES that there is <3 PSI in the air valve.

- When the beamline is Global Online and Beam Active: If the <3 PSI input is ON, the program will close the FES, generate a fault, and remove permit(s) to the critical devices.

- When the beamline is Global Online and NOT Beam Active: If this input is ON, the program will generate a fault and remove permit(s) to the critical devices.
- When the beamline is in any other condition: If the <3 PSI input is ON, the program will fault and will withhold permit(s) to critical devices.

6.1.12 FE Shutter Pressure (>60 PSI)

FES pressure air valve. Indicator for the FES that there is >60 PSI in the air valve.

- When the beamline is Beam Active: If the >60 PSI input is OFF, the program will close the FES, generate a fault, and remove permit(s) to critical devices.
- When the beamline is in any other condition: If the >60 PSI input is OFF, the program will fault and will withhold permit(s) to critical devices.

6.1.13 ACIS Trip Test Pushbutton

Permit to ACIS interface test injection point. When permit is OFF, the ACIS program will remove permit to the stored beam.

6.1.14 Chain-A 24Vdc Field Power Supply Active/OK

This monitors the Chain-A 24VDC field power supply.

- When the beamline is beam Active: If this input is OFF, the program will fault and remove permit(s) to critical devices.
- When the beamline is in any other condition: If this input is OFF, the program will fault and withhold permit(s) to critical devices.

6.1.15 Mezzanine Test Connector Box Open

This monitors the Test Connector Box interface. When input is OFF, the program is given 2 seconds to close the FES and remove permit(s) to critical devices, before ACIS takes action (Stored beam dump).

6.1.16 Any Test Connector Box Open

This monitors the Test Connector Box interface. When input is OFF, the program is given 2sec. to close FES and remove permit to critical device, before ACIS takes action (Stored beam dump).

6.1.17 Photon Stop 1 Opened Limit Switch (PS1_Opened_LS)

The FES PS1 Opened limit switch input.

- Station secured and FES not open: If this input is ON, the program will fault and remove permit(s) to critical devices.
- Station not secure and FES not open: If this input is ON, the program will remove Storage Ring permit and remove permit(s) to critical devices.

6.1.18 Photon Stop 1 Closed Limit Switch (PS1_Closed_LS)

The FES PS1closed limit switch input.

- Station secured and FES not open: If this input is OFF, the program will fault and remove permit(s) to critical devices.
- Station not secure and FES not open: If this input is OFF, the program will remove Storage Ring permit and remove permit(s) to critical devices.

6.1.19 Photon Stop 2 Opened Limit Switch (PS2_Opened_LS)

The FES PS2 Opened limit switch input.

- Station secured and FES not open: If this input is ON, the program will fault and remove permit(s) to critical devices.
- Station not secure and FES not open: If this input is ON, the program will remove Storage Ring permit and remove permit(s) to critical devices.

6.1.20 Photon Stop 2 Closed Limit Switch (PS2_Closed_LS)

The FES PS2 closed limit switch input.

- Station secured and FES not open: If this input is OFF, the program will fault and remove permit(s) to critical devices.
- Station not secure and FES not open: If this input is OFF, the program will remove Storage Ring permit and remove permit(s) to critical devices.

6.1.21 Safety Stop 1 Opened Limit Switch (SS1_Opened_LS)

The FES SS1Opened limit switch input.

- Station secured and FES not open: If this input is ON, the program will fault and remove permit(s) to critical devices.
- Station not secure and FES not open: If this input is ON, the program will remove Storage Ring permit and remove permit(s) to critical devices.

6.1.22 Safety Stop 1 Closed Limit Switch (SS1_Closed_LS)

The FES SS1closed limit switch input.

- Station secured and FES not open: If this input is OFF, the program will fault and remo ve permit(s) to critical devices.
- Station not secure and FES not open: If this input is OFF, the program will remove Storage Ring permit and remove permit(s) to critical devices.

6.1.23 Safety Stop 2 Opened Limit Switch (SS2_Opened_LS)

The FES SS2Opened limit switch input.

- Station secured and FES not open: If this input is ON, the program will fault and remove permit(s) to critical devices.
- Station not secure and FES not open: If this input is ON, the program will remove Storage Ring permit and remove permit(s) to critical devices.

6.1.24 Safety Stop 2 Closed Limit Switch (SS2_Closed_LS)

The FES SS2 closed limit switch input.

- Station secured and FES not open: If this input is OFF, the program will fault and remove permit(s) to critical devices.
- Station not secure and FES not open: If this input is OFF, the program will remove Storage Ring permit and remove permit(s) to critical devices.

6.1.25 Photon Stop 1 Safe to Open Permit

PS1 open permit. When all conditions are satisfied, this output provides the permit for PS1 to open.

6.1.26 Photon Stop 2 Safe to Open Permit

PS2 open permit. When all conditions are satisfied, this output provides the permit for PS2 to open.

6.1.27 Safety Stop 1 Safe to Open Permit

SS1 open permit. When all conditions are satisfied, this output provides the permit for SS1 to open.

6.1.28 Safety Stop 2 Safe to Open Permit

SS2 open permit. When all conditions are satisfied, this output provides the permit for SS2 to open.

6.1.29 Photon Stop 1 Closed Limit Switch to ACIS

PS1 closed limit switch status output to ACIS.

6.1.30 Photon Stop 1 Opene d Limit Switch to ACIS

PS1 opened limit switch status output to ACIS.

6.1.31 Photon Stop 2 Closed Limit Switch to ACIS

PS2 closed limit switch status output to ACIS.

6.1.32 Photon Stop 2 Opened Limit Switch to ACIS

PS2 opened limit switch status output to ACIS.

6.1.33 Safety Stop 1 Closed Limit Switch to ACIS

SS1 closed limit switch status output to ACIS.

6.1.34 Safety Stop 1 Opened Limit Switch to ACIS

SS1 opened limit switch status output to ACIS.

6.1.35 Safety Stop 2 Closed Limit Switch to ACIS

SS2 closed limit switch status output to ACIS.

6.1.36 Safety Stop 2 Opened Limit Switch to ACIS

SS2 opened limit switch status output to ACIS.

6.1.37 Storage Ring Permit

Storage Ring permit to ACIS. If the output is OFF, ACIS will abort stored beam.

6.1.38 Testing Acknowledged

Confirmation that test cart may proceed with test mode.

6.2 Station Slave PLC

This section describes the Experimental floor PLCs' functions and interface.

6.2.1 Station User Key Enabled

Enable station search and secure permit.

- Station secured: If this input is OFF, the program will remove permit to the critical devices.
- Beam Active: If this input is OFF, the program will close the shutter and remove its permit.

6.2.2 Station APS Key Enabled

Enable shutter permit, allow critical device to open.

- Station secured: If this input is OFF, the program will remove permit(s) to the critical devices.
- Beam Active: If this input is OFF, the program will close the shutter and remove its permit.

6.2.3 Major/Serious Reset Key Switch

Kirk lock key for the Major or Serious fault reset. Fault will only reset when conditions are satisfied.

6.2.4 Station-A Test Connector Box Open

Test interface box at Station-A.

- When the beamline is Global Online and the FES is open: If this input is OFF, the program will close the FES in <2 seconds and remove permit(s) to critical devices.
- When the beamline is Global Offline: If this input is OFF, the program will withhold permit(s) to critical devices.

6.2.5 Station Door Sensor

Station door mechanical switch input, open input is OFF and closed input is ON.

- FES not open: If this input is OFF, there will be no resulting action.
- Station FES open: If this input is OFF, the program will remove the Storage Ring permit and withhold permit(s) to critical devices.

6.2.6 Station Emergency Stop Button

Emergency Stop Button input. These inputs are normally closed and are actuated when OFF.

- When the station is Beam Active: If this input is OFF, the program will remove the Storage Ring permit and remove permit(s) to critical devices.
- When the station is secured: If this input is OFF, the program will fault and remove permit(s) to critical devices.
- When the station is not secure: If this input is OFF, there will be no resulting action.

6.2.7 Station Search From Chain-A

Station Search input from Chain-A. When this input is ON, the relevant station is searched and secured.

6.2.8 MS1 Opened Limit Switch (MS1_Opened_LS)

The MS1 opened limit switch input, indicator that the MS1 cylinder is opened.

- While this shutter is closed: If this input is ON, the program will fault and remove permit(s) to critical devices.
- While this shutter is opened: If this input is OFF, the program will close the shutter and withhold permit(s) to critical devices.

6.2.9 MS1 Closed Limit Switch (MS1_Closed_LS)

The MS1 closed limit switch input, indicator that the MS1 cylinder is closed.

- While this shutter is opened: If this input is ON, the program will fault and remove permit(s) to critical devices.
- While this shutter is opened: If this input is OFF, the program will close the shutter and r withhold permit(s) to critical devices.

6.2.10 MS2 Opened Limit Switch (MS2_Opened_LS)

The MS2 opened limit switch input, indicator that the MS2 cylinder is opened.

- While this shutter is closed: If this input is ON, the program will fault and remove permit(s) to critical devices.
- While this shutter is opened: If this input is OFF, the program will close the shutter and withhold permit(s) to critical devices.

6.2.11 MS2 Closed Limit Switch (MS2_Closed_LS)

The MS2 closed limit switch input, indicator that the MS2 cylinder is closed.

- While this shutter is opened: If this input is ON, the program will fault and remove permit(s) to critical devices.
- While this shutter is opened: If this input is OFF, the program will close the shutter and withhold permit(s) to critical devices.

6.2.12 PS Opened Limit Switch (PS_Opened_LS)

The PS opened limit switch input, indicator that the PS cylinder is opened.

- While this shutter is closed: If this input is ON, the program will fault and remove permit(s) to critical devices.
- While this shutter is opened: If this input is OFF, the program will close the shutter and withhold permit(s) to critical devices.

6.2.13 PS Closed Limit Switch (PS_Closed_LS)

The PS closed limit switch input, indicator that the PS cylinder is closed.

- While this shutter is opened: If this input is ON, the program will fault and remove permit(s) to critical devices.
- While this shutter is opened: If this input is OFF, the program will close the shutter and withhold permit to critical device.

6.2.14 SS Opened Limit Switch (SS_Opened_LS)

The SS opened limit switch input, indicator that the SS cylinder is opened.

- While this shutter is closed: If this input is ON, the program will fault and withhold permit(s) to critical devices.
- While this shutter opened: If this input is OFF, program will close shutter and remove permit to critical device.

6.2.15 SS Closed Limit Switch (SS_Closed_LS)

The SS closed limit switch input, indicator that the SS cylinder is closed.

- While this shutter is opened: If this input is ON, the program will fault and remove permit(s) to critical devices.
- While this shutter is opened: If this input is OFF, the program will close the shutter and remove permit(s) to critical devices.

6.2.16 Shutter MS1 Permit

MS1 open permit. When all conditions are satisfied, this output provides permit for MS1 to open.

6.2.17 Shutter MS2 Permit

MS2 open permit. When all conditions are satisfied, this output provides permit for MS2 to open.

6.2.18 Shutter PS Permit

PS open permit. When all conditions are satisfied, this output provides permit for PS to open.

6.2.19 Shutter SS Permit

SS open permit. When all conditions are satisfied, this output provides permit for SS to open.

6.2.20 Shutter Pressure OK to Operate Permit

>60 PSI integral pressure ok switch input. When this input is ON, the program will provide permit to its shutter.